Data Acquisition with 2D Detectors at the ESRF

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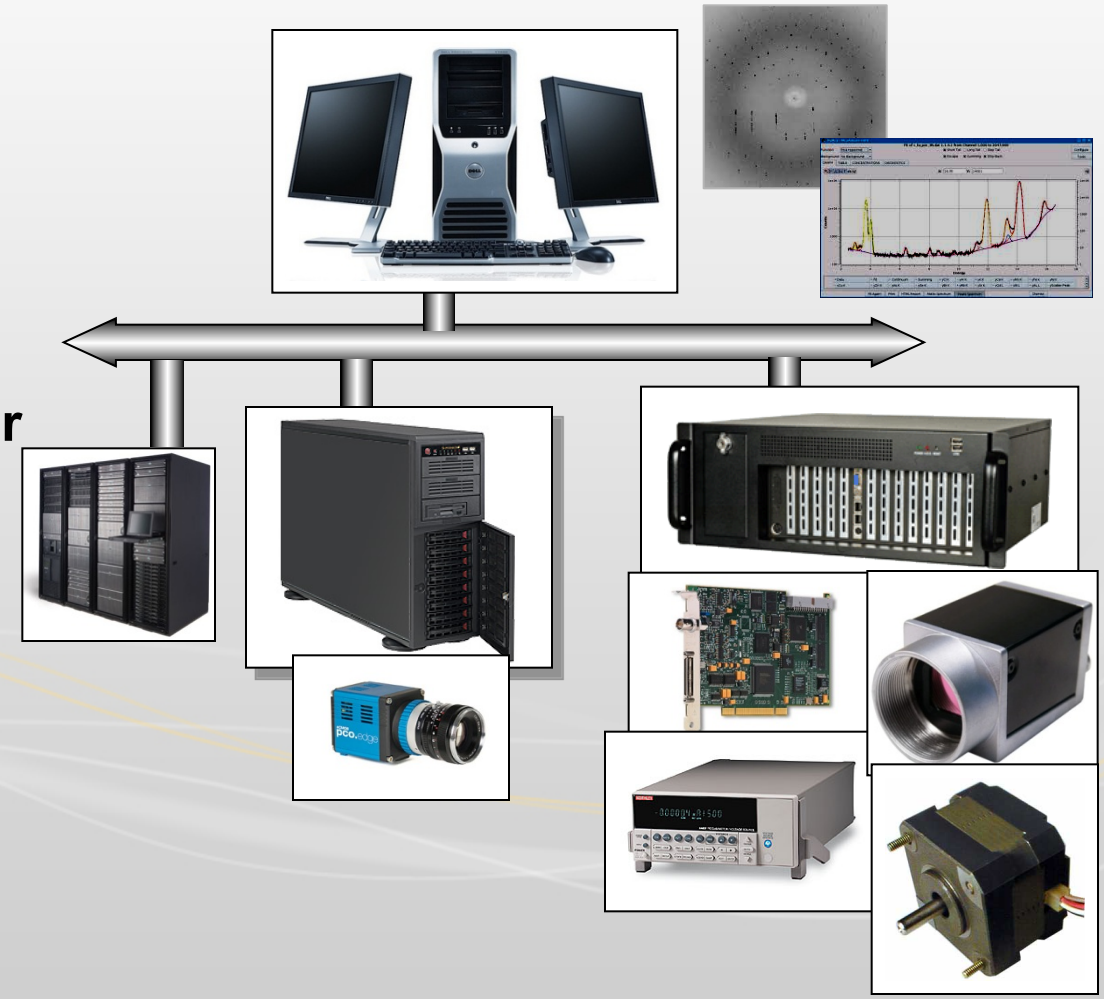
Talk outline

- Introduction
  - ESRF BL control system
  - 2D detector control
- The LIMA project
  - Goals & Features
  - Detectors & Applications
- Next generation
  - Current limitations - New functionality
  - Foreseen detectors

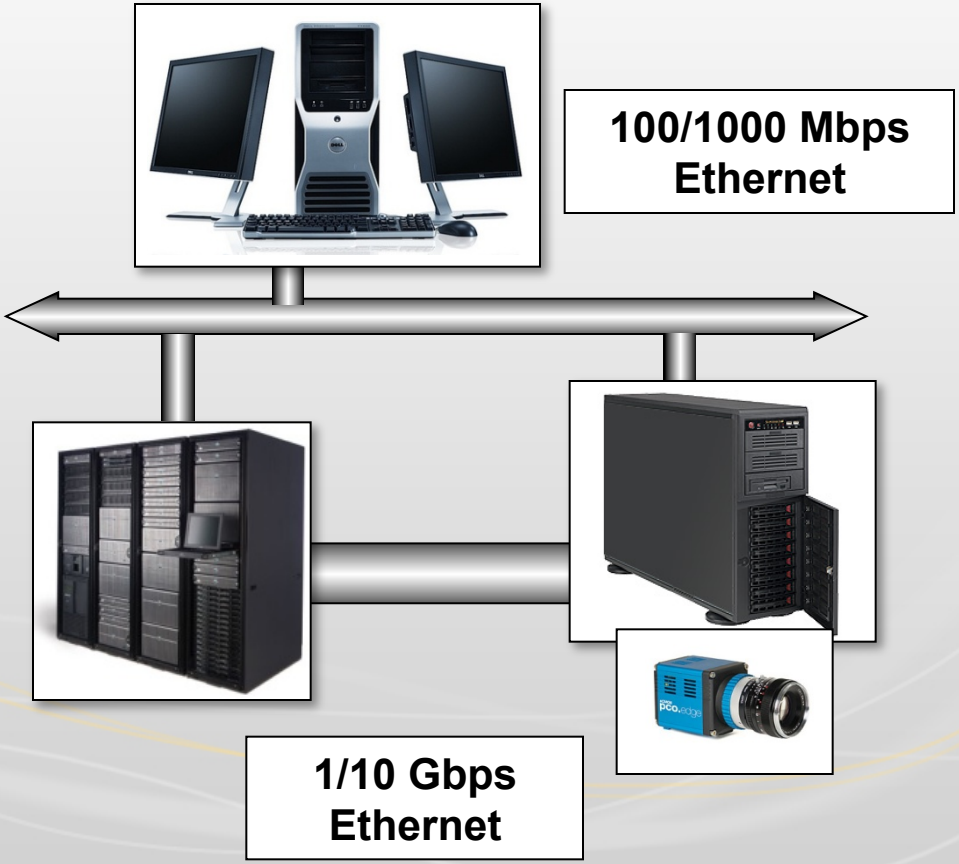
ESRF BL control system

- Distributed hardware
- TACO/TANGO middleware
- Device servers
- User control workstation
  - Experiment orchestrator
  - SPEC
    - Hardware coordination
  - GUI panels



Controlling 2D detectors

- About 20 different detectors
- High performance PCs
  - 90 - 150 MB/s
- Generic interfaces:
  - SPEC image abstraction
  - TACO/TANGO interface
  - LibCCD
    - Difficult back-port
- Explored areaDetector
  - Intrinsic EPICS dependency



LIMA Goals

- Library for Image Acquisition
- Control system-independent
- Oriented to high-speed detectors
  - Favour the use of detector optimizations
  - Highly multi-threaded
  - Minimize memory copy operations
- Common control functionality
  - Provide software alternatives to “missing” hardware capabilities
- Modular design for simpler integration of extensions
- C++, Python/SIP

Library structure layout

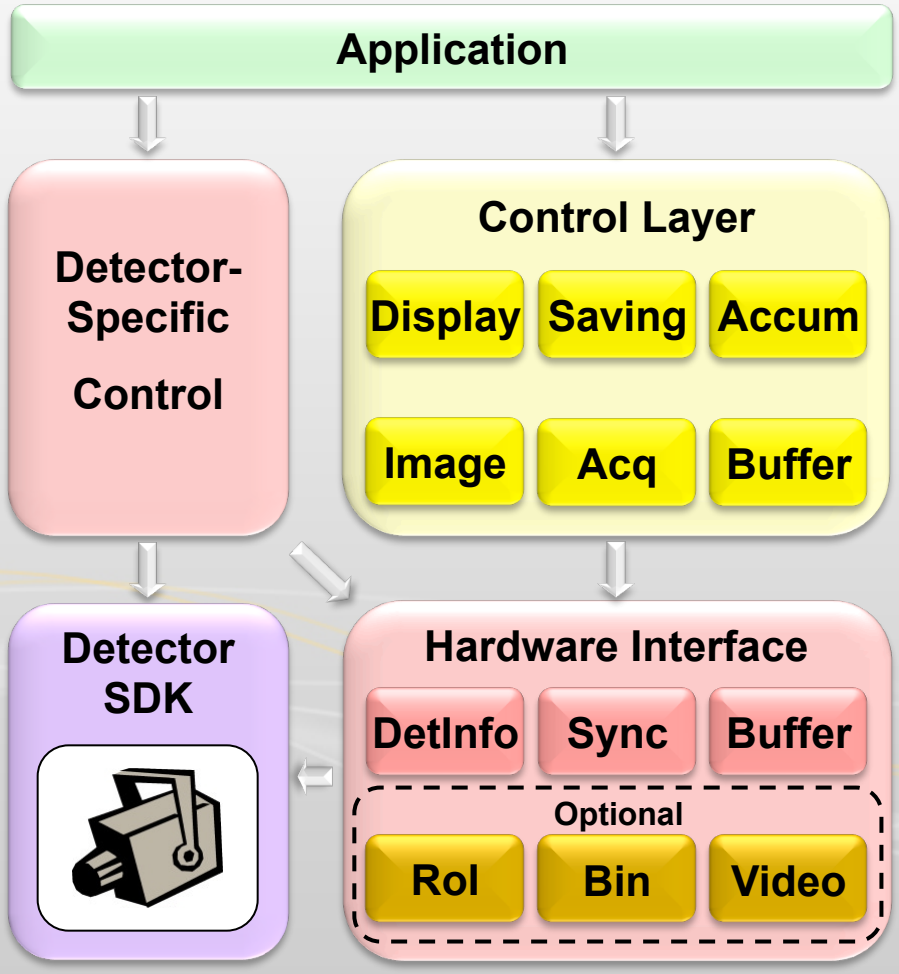
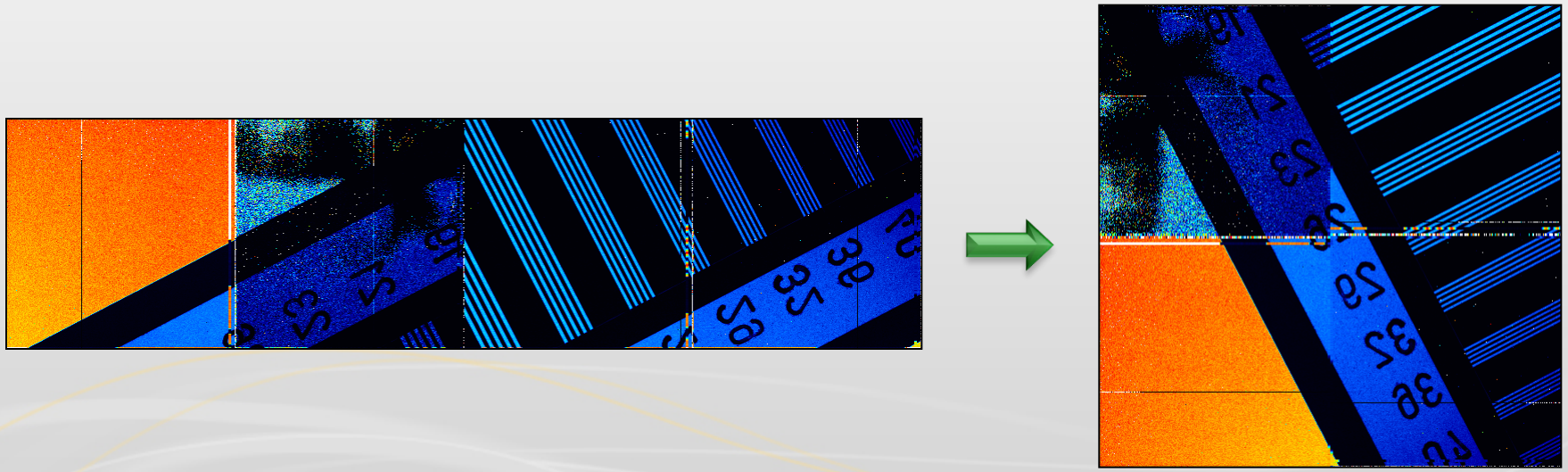


Image Reconstruction

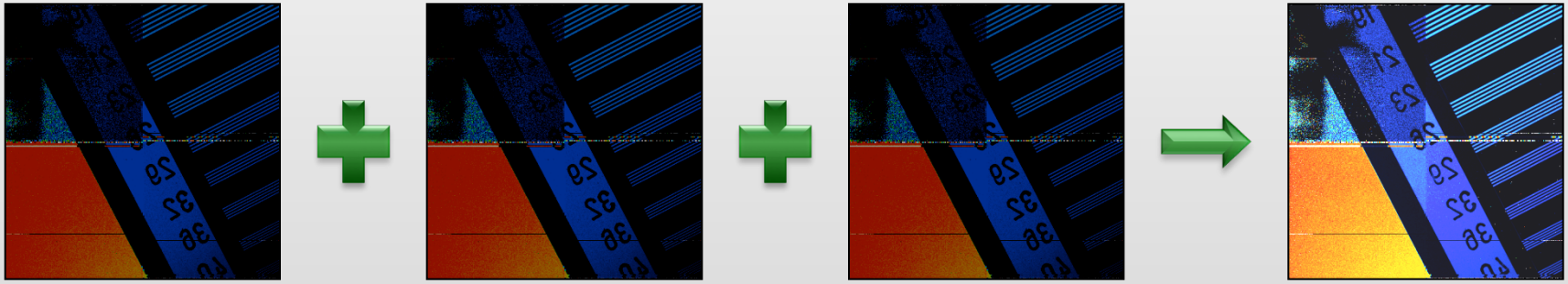
- Data readout sequence does not follow real geometry



- Detector specific
- Before any other manipulation

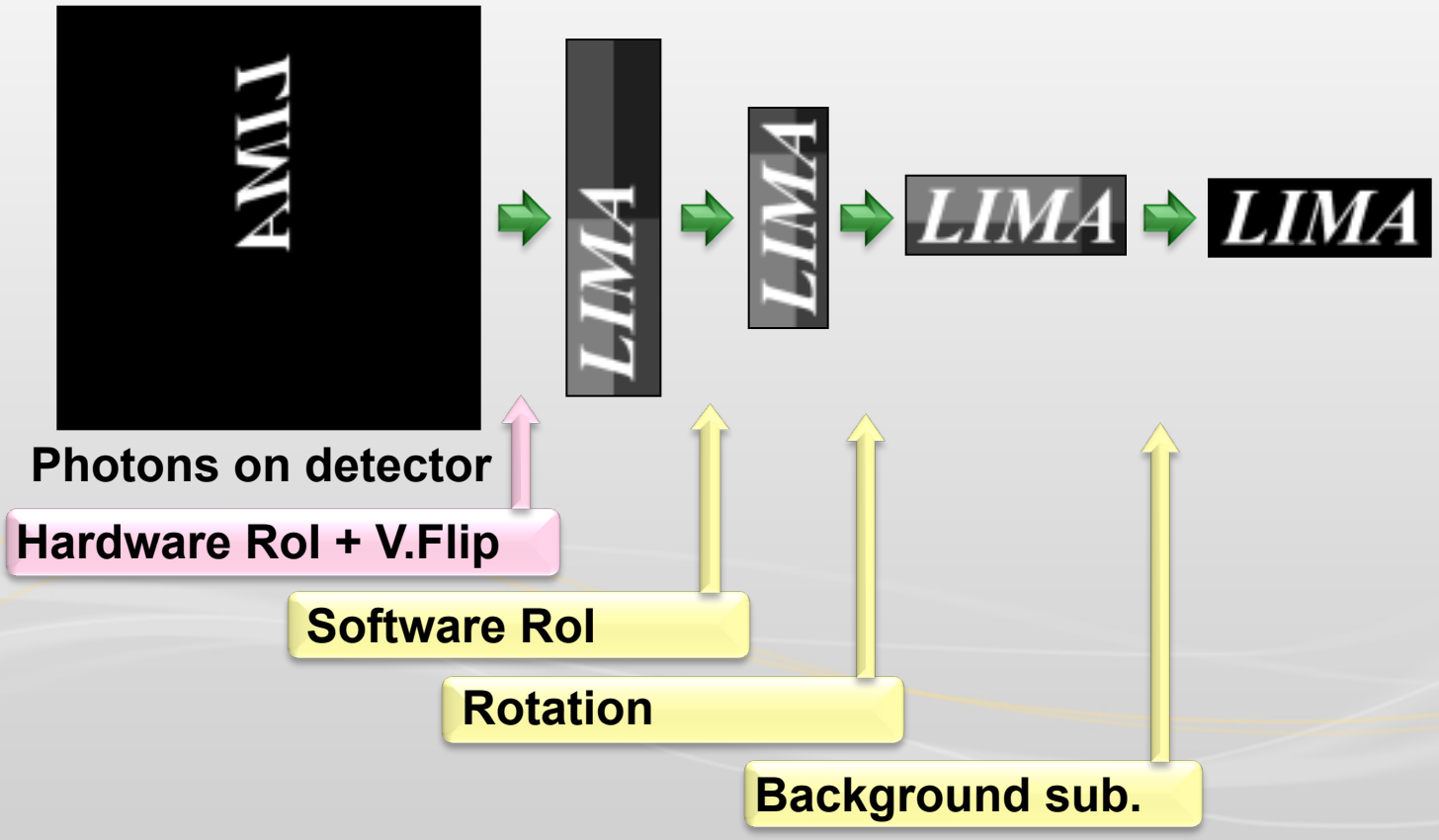
Pixel Accumulation

- Limited hardware integration: either in time or capacity

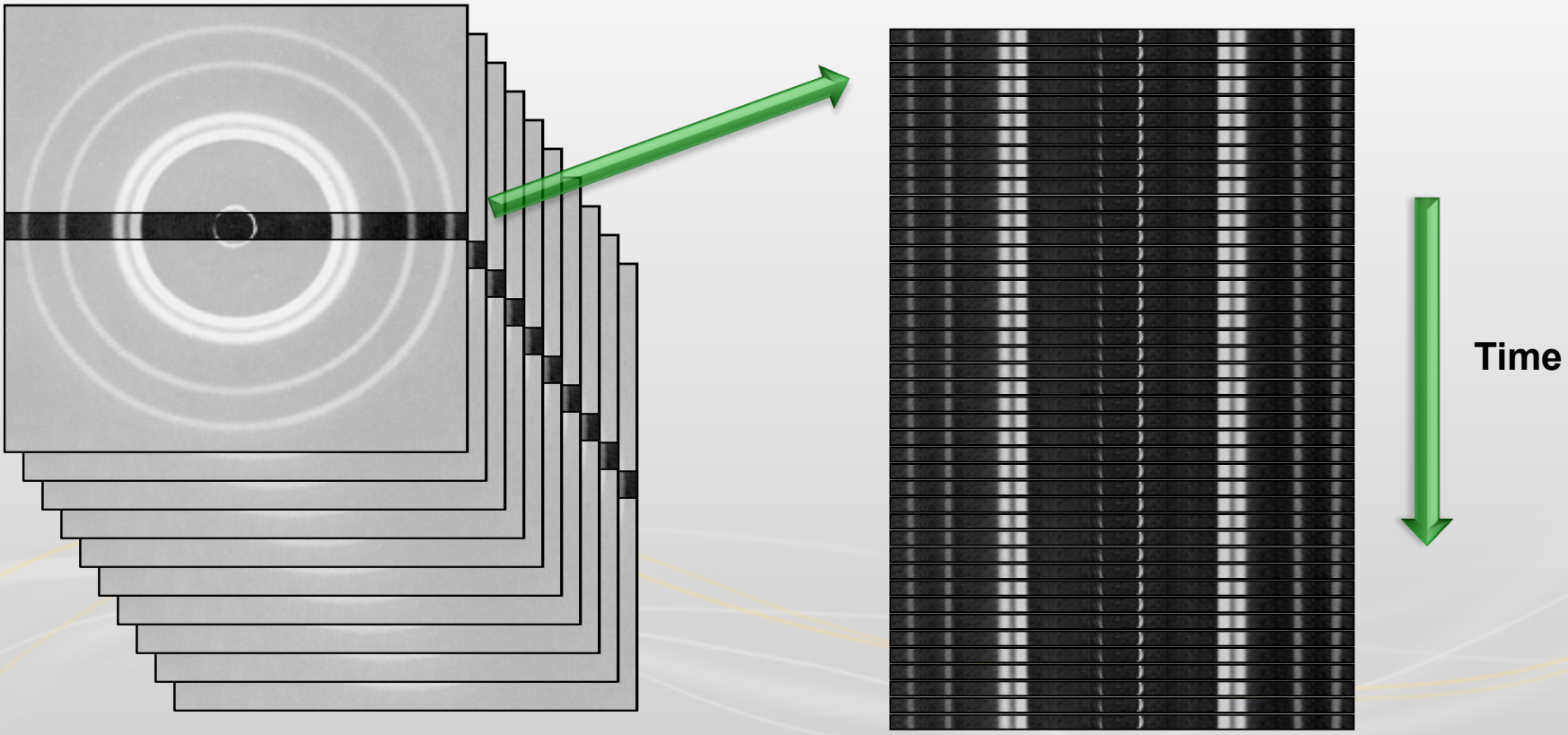


- Detect saturation (each frame) to signal non-linearity
- Intensity threshold ⇨ sensor protection

Image transformations



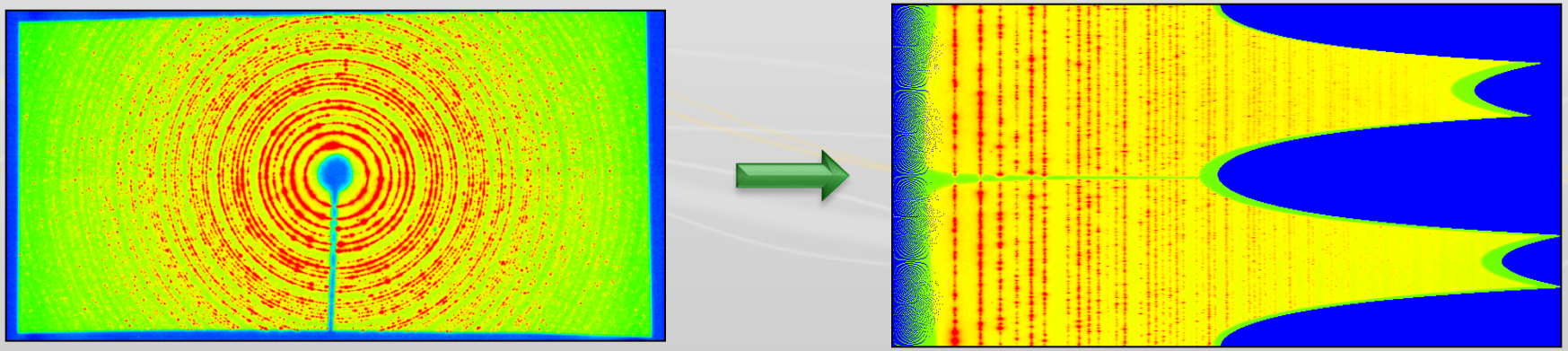
Stripe Concatenation



- High frame rate
- Powder diffraction, imaging and absorption spectroscopy

Data reduction

- Multi-RoI Statistics ⇨ Scalar counters
- Centroid (Beam Position Monitoring)
- Flat-field normalisation
- Image Mask
- Spatial distortion correction
- pyFAI ⇨ Fast Azimuthal Integration in Python



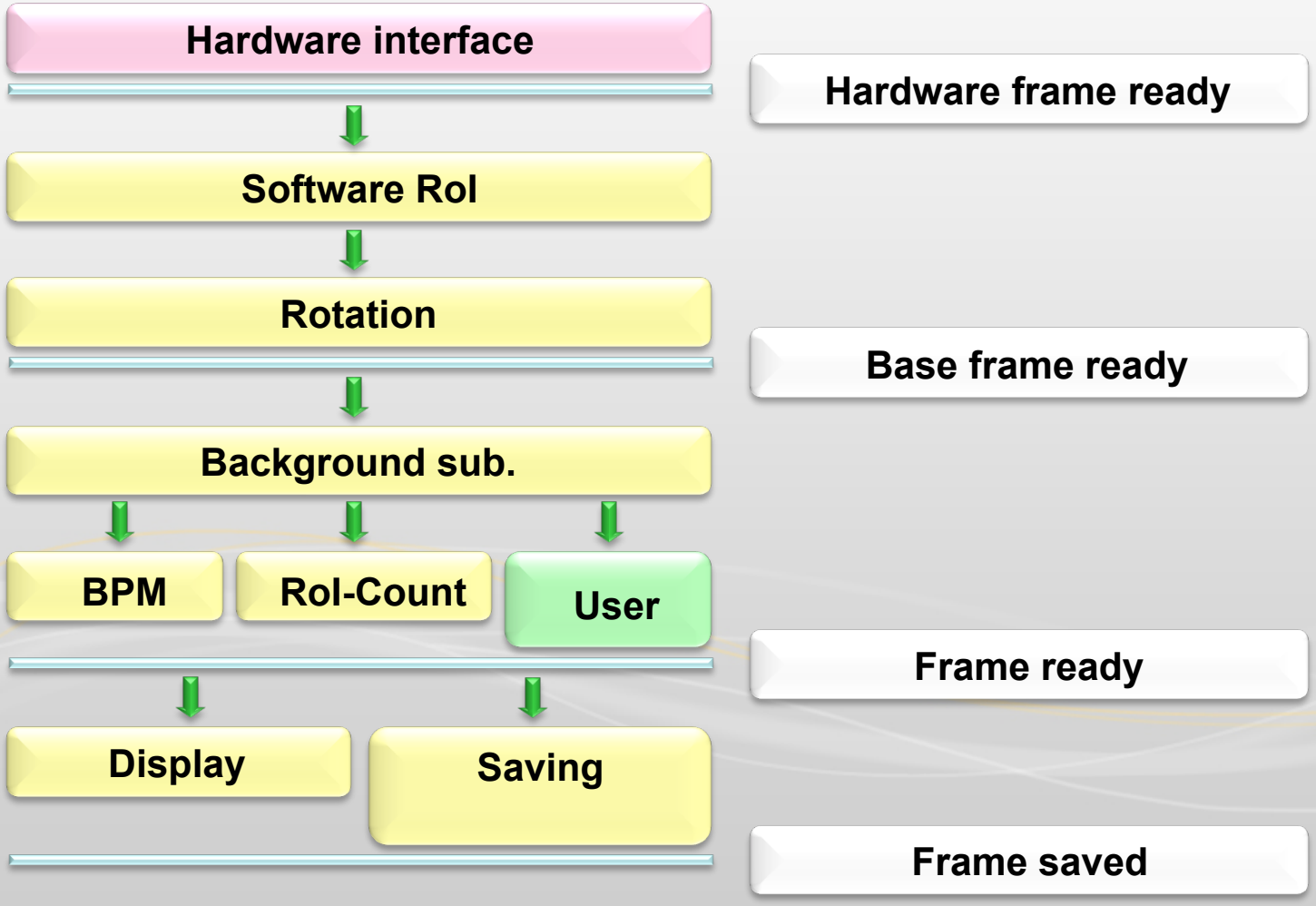
Data saving

- Automatic & manual file saving
  - EDF, CBF
- Different metadata components:
  - Static – detector type
  - Scan – sample name, scan conditions
  - Frame:
    - Internal – timestamp, CPU processing time
    - External – user defined: SR current, monitor intensity
- Data rate
  - 2 – 250 MB/s

Other features

- Basic video interface
  - Common video modes (mono/color)
  - Gain control
- External user processing plug-ins
  - Arbitrary operations

Frame processing & Events



Detectors at the ESRF

- 14 ESRF Frelon
- 14 ESRF Maxipix (Single chip, 2x2, 5x1)
- 10 Dectris Pilatus (300w, 1M, 2M, 6MF)
- 21 Basler
- 3 Prosilica
- 1 IDS uEye
- 2 Andor I-Kon
- 2 XPAD
- 4 PCO.Dimax & Edge
- 2 Perkin Elmer flat panel
- 2 Photonic Science
- 75 Total … and increasing …

LIMA collaboration

- SOLEIL
- PETRA-III / DESY
- FRM-II / TUM
- ALBA
- MAX-Lab
- ADSC
- Rayonix
- CCLRC / STFC
- Nexeya Systems
- ILE/LULI/Ecole Polytechnique

Applications

- In production for about 3 years
  - In more than 20 BLs
- TANGO device servers + SPEC

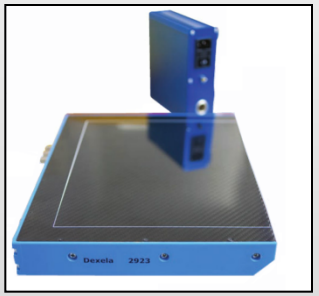
- Fast imaging & tomography
- Fast spectroscopy & diffraction
- Ptychography
- GISAXS
- Beam Position Viewer & Monitoring
- Sample visualization (microscope)

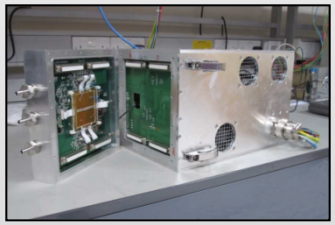
Current limitations & New Functionality

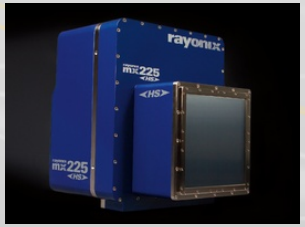
- Delayed data processing & saving ⇨ dead time between scans
  - Need deferred frame processing
- Buffer memory management:
  - Tracking of frame buffer usage
- Detector per-frame meta-data
- Sinogram (slice concatenation), Azimuthal (polar) RoI counters
- More flexible saving management:
  - Gradual migration to HDF-5 at the ESRF

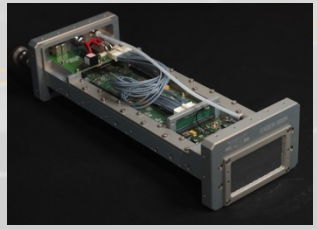
Foreseen Detectors

- **Legacy:**
  - **Sarnoff, Dalsa, Aviex**
- **Under development:**
  - **Dexela CMOS flat panel**
  - **XH/XChip3**
  - **Rayonix HS**
- **New:**
  - **Pilatus III**
  - **PSI Eiger**









Conclusions

- LIMA is a library for 2D detector control
- Oriented to high performance acquisitions
- Provides common functionality for a variety of detectors
  - Image transformations
  - Data reduction algorithms
- In operation at the ESRF on 20 BLs
- Collaboration community around LIMA
- Developments on new detector plugins and acquisition strategies

Acknowledgements

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  - BCU, DAU, ACU

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Thank you for your attention!